"Wood, Thomas" <TRWOOD@stoel.com>
04/07/2006 12:19 PM

To Margaret Alkon/R9/USEPA/US@EPA

cc "Rick Abel (E-mail)" <Rick.Abel@bhpbilliton.com>, "Renee Klimczak (E-mail)" <Renee.Klimczak@bhpbilliton.com>, "Kevin Wright (E-mail)" <kwright@entrix.com>, "Kathi Hann

bcc

Subject Response to Information Requests

History: This message has been replied to and forwarded.

Margaret: Attached please find a letter responding to your information requests. Included with the letter is the requested Errata sheet and also replacement copies of Appendix A and Appendix C. These replacements reflect some updated information as well as edits suggested by the questions. One of the updates is that BHP received a new specification for the Wartsila engines being used for FSRU power generation. A copy of that specification is also included for your records.

My understanding is that with this letter BHP will have responded to all of air related questions that have been posed to the company by EPA. Please let me know if you believe that this is not the case.

Thanks.

Tom

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4-6-06 Ltr to Alkon.pdf Attachment 1.pdf Attachment 2.pdf Attachment 3.pdf W 50 DF emission.pdf

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April 7, 2006

VIA EMAIL & U.S. MAIL

Ms. Margaret Alkon
ORC-2
United States Environmental Protect Agency
Region 9
75 Hawthorne Street
San Francisco, CA 94105

Re: BHP Billiton LNG International Inc.; Cabrillo Port
Response to Information Requests

Dear Margaret:

By emails dated March 14, 2006, March 29, 2006 and March 30, 2006 you requested responses to questions raised by the BHP Billiton LNG International ("BHP") preconstruction air permit application. This letter is intended to answer each of the questions you raised in those emails.

EPA March 14, 2006; Question 1: *Page 2-10 says that diesel will be used to operate a crane onboard the FSRU. However, page 3-4 says that the cranes used for material handling will be electric. Please clarify what types of cranes will be used.*

As noted, the application inadvertently states at page 2-10 that the on-board cranes will be diesel fired. This was an error. The description on page 3-4 accurately states that the on-board material handling crane will be electric. This point is corrected via the attached errata sheet.

EPA March 14, 2006; Question 2: *Is the sulfur content in the diesel burned in the Wartsila 9L50DF engines 1 ppm by weight or by volume?*

References to "ppm" in relation to the fuel sulfur content in the gas should be stated as "ppmv." References to "ppm" in relation to the fuel sulfur content in the diesel should be stated as "ppmw." This point is corrected in the revised emissions inventory spreadsheets included with this letter. Please note that the sulfur content in the diesel is neither 1 ppm by weight nor by volume; the sulfur content in the gas is 1 ppmv and the sulfur content in the diesel is 15 ppmw.

EPA March 14, 2006; Question 3: *The application says that diesel will be used in monthly tests of the power generator and firewater pumps to ensure their continued operability. Since the Wartsila backup generator will potentially have limited use on diesel during emergencies, will monthly testing on diesel also be necessary for this engine?*

The emergency power generator and firewater pump engines are exercised periodically in order to ensure that they are in operating condition in the event of an emergency. As noted, they operate on diesel and will be exercised using diesel fuel. In contrast, the Wartsila 9L50DF generator engines are intended to operate on gas at all times (with 0.6% diesel pilot fuel (heat input basis)). However, as the application identifies at page 3-2 the Wartsila generator engines have dual fuel capacity and so could burn exclusively diesel in the event that the gas supply was interrupted. Backup operations using exclusively diesel are limited to the equivalent of one Wartsila engine operating 100 hours per year; this equates to a total of 48,417 gallons of diesel fired in the Wartsila generator engines for backup operations. Each of the four Wartsila generator engines could be periodically tested on diesel. However, there is no regular exercise routine planned for them at this time as there is for the emergency generator and firewater pumps. To the extent that the Wartsila generator engines are periodically tested on diesel, the fuel usage will be maintained at less than 48,417 gallons per year.

EPA March 14, 2006; Question 4: *Page 4-11 demonstrates compliance with the 300 ppmv and 10 ppmv limits at the point of discharge but the demonstration is not so clear for the sea level concentrations at the property line. Did BHP model to show that these concentrations would not be exceeded? Also, contrary to what is indicated in the Cabrillo Port air permit application, the rule does not have separate requirements for point sources and area sources; the requirements of Rule 54(B) apply to all sources.*

No modeling is necessary to demonstrate compliance with these limits. The Project is not anticipated to emit H_2S and so there is no concern that concentrations would exceed 10 ppmv at the edge of the exclusion zone, which is the equivalent to the property line for this source. Nor is SO_2 a concern. The emission spreadsheets document the maximum SO_2 emission rates for all of the equipment. The SO_2 concentration from the SCVs at the discharge point is 0.1 ppmv; the SO_2 concentration from the Wartsila engines at the emission point is 0.034 ppmv on gas and 0.29 ppmv on diesel. The firewater pump, emergency generator and lifeboat engine, all fired on diesel, emit in the aggregate less than 1 ppmv SO_2. With eight SCVs and four Wartsila engines, the maximum SO_2 emissions, even if every unit was simultaneously operating, would be only approximately 3 ppmv SO_2 at the point of discharge. There is no concern that the Project would exceed 300 ppmv at the edge of the exclusion zone, 500 meters away. Therefore, no modeling

was performed. We acknowledge that the rule does not distinguish between point and area sources.

EPA March 14, 2006; Question 5: *Table FSRU 4 indicates that the exhaust temperature for the main generators will be 800 degrees F. What is the minimum temperature at which the SCR catalyst becomes effective?*

The typical minimum temperature at which an SCR catalyst is effective is 650°F. Although the exact catalysts have not yet been identified, BHP anticipates that this will be the low end temperature. However that cannot be stated with certainty until the catalyst manufacturer and type are identified. BHP anticipates that the generator engines will reach minimum temperature on their exhaust gas in less than an hour.

EPA March 14, 2006; Question 6: *The g/hW-hr emission rates in Table FSRU 11: Firewater Pumps Emission Summary are the same for the firewater pumps and emergency engine (see next page) except for SO2. Is one of these a typo?*

There is no typo in the emissions estimates. The particular make and model of the firewater pumps and emergency generator engine have not yet been specified. Therefore, it is necessary that BHP make conservative estimates of the emission factors. As the engines will all be subject to the EPA Tier 2 emission standards in 40 CFR § 89.112, BHP conservatively used those maximum allowable emission rates as the emission factors. As the Tier 2 standards are the same for both the firewater pump and emergency generator engines, the NOx, VOC (NMHC), CO and PM emission factors are all identical as between the two types of engines. However, because there is no Tier 2 standard for SO_2, the SO_2 emissions factors were derived based on the engine efficiency and the maximum allowable sulfur content of the fuel. The greater the engine efficiency , the lower the SO_2 emissions as follows:

Engine Type	Efficiency	SO2 Emissions (g/bhp-hr)
Firewater Pump	35 %	0.005
Emergency Generator	40 %	0.004
Freefall Lifeboat	30 %	0.006

The engine efficiency is currently listed as a parameter on each spreadsheet.

As a result, the emission factors for the firewater pump engines and the emergency generator engines are the same for all regulated pollutants other than SO_2.

EPA March 14, 2006; Question 7: *In the Table entitled Operating Emissions Summary it appears as though one of the Wartsila engines will specifically be designated as the backup. Please confirm that this means the following: 1) for normal operations, the three main generators will always be used when they are capable of operating and the backup generator will only be used when one of the three main generators goes down for maintenance.; 2) although all of the Wartsila engines are dual fueled, the backup engine will be the only one that actually fires on diesel during emergency situations (limited to 100 hours per year).*

There is no specific Wartsila engine that is designated the back-up unit. All four have dual fuel firing capability. The operation of the units will be circulated as needed to allow periodic servicing of each engine. If the gas supply were interrupted the operators would make a decision at the time as to which engine would be operated on diesel. This design allows much greater flexibility and safety in the unlikely event that gas is unavailable. As noted above, to the extent that the Wartsila generator engines are ever operated on exclusively diesel, the fuel usage will be maintained at less than 48,417 gallons per year.

EPA March 30, 2006; Question 1: *The application implies that the FSRU will have a continuous supply of LNG and therefore will have a continuous supply of BOG on which to operate the main generator engines. However, that fact does not appear to be explicitly stated anywhere in the permit application. Please confirm that under normal operations, the intent is for the FSRU to have a constant supply of BOG.*

The intent is for the FSRU to have a continuous supply of boil-off gas ("BOG"). However, if the FSRU were to ever not have adequate LNG in storage to generate the needed BOG, one of the Wartsila generator engines would be capable of operating on diesel long enough to shut down (or start up).

SCAQMD Question 1: *I also found an error in their emission calculations for the large 8 MW dual-fuel generators (App. G2, Table FSRU 5) on board the FSRU (floating terminal) that result in underestimating all generator emissions by 10% percent. The EPS Method 19 F-factor they used of 8713 (actually should be 8710) dscf/MMBtu of natural gas burned is based on MMBtu of higher heating value (HHV), but I believe the Wartsila specs (7239 Btu/kW-hr and 47.1% eff.) they used to compute the MMBtu/hr consumed are based on lower heating value of natural gas. The stated efficiency and heat rate of the engines is impossible based on HHV (and even questionable high based on LHV), therefore they are probably based on lower heating value,*

which is customary in the engine industry. Since HHV is about 10% more than LHV for natural gas, the calculated heat input rates, exhaust flowrates and mass emissions will be about 10% higher if the Wartsila specs are converted to HHV.

SCAQMD's comment breaks down into two points. First, SCAQMD suggested that BHP erred in calculating the F-factor. South Coast suggested it should be 8710 instead of 8713. This comment is incorrect. The Method 19 F-factor is corrected to reflect the fact that the engines fire 99.4% gas and 0.6% diesel pilot fuel (heat input basis). When this mix and the fuel specific F-factors in Table 19-2 are taken into account, the value used in the application are accurate, as demonstrated below:

$F_d = (0.006)(9190) + (0.994)(8710) = 8713$ dscf/MMBtu

Also, for the Wartsila generator engines, the sulfur content of the 1 ppmv sulfur gasified LNG fuel is corrected for 0.74% (fuel mass basis) of 15 ppmw sulfur California diesel pilot fuel. This yields an SO_2 correction factor of 1.0484, about 5% more than burning only gasified LNG. The 0.994/0.006 (heat input) split applies only to the Wartsila 9L50DFs on gas.

Second, South Coast suggests that the emission estimates were off due to our applying HHV to an LHV-based emission factor. Emissions of NOx, VOC, CO, PM_{10}, and CO_2 were not underestimated. The Wartsila emission factors for NO_X , VOC, CO, PM_{10} , and CO_2 are in mass per unit output (i.e., g/kw-hr), not mass per unit input (e.g., lb/MMBtu). These factors are unaffected by heat input, i.e., LHV or HHV of fuel gas. Thus, these emissions are correctly calculated. However, the reviewer's comment is accurate in relation to the SO_2 emissions which are based on mass per unit input. These emissions increase slightly as the result of correcting LHV to HHV. Correcting LHV to HHV increases the heat rate by 10%, from 7239 to 7963 Btu/kw-hr (42.9% efficiency dual fuel mode) which also increases heat input from 179.17 to 197.08 MMBtu/hr for all three (3) engines. Since SO_2 is concentration-based, FSRU SO_2 increases from 0.41 to 0.42 tpy. It is worth noting that since heat input increases, stack velocity also increases from 53.6 to 59.0 m/sec, thus improving dispersion. These changes are reflected in the revised emissions inventory spreadsheets included with this letter.

SCAQMD Question 2: *Also, for the tugs and crew boats they are using EPA emission factors for 4-cycle, lean-burn natural gas engines. But these vessels will be compression-ignition, dual-fuel engines (with diesel pilot fuel) which can have much higher NOx emissions than what was calculated. Since they are dedicated vessels, they should get actual engine specs like they did*

for the equipment on the FSRU. (BHP told us in the meeting they think they will may get even lower NOx engines (1.3 g/kW-hr or 1.0 g/bhp-hr) from Wartsila. This is very good, but If so, it should be a committed mitigation measure.)

The South Coast commenter suggests that BHP obtain actual engine specifications for the tugs. As South Coast indicates, in response to CARB's request that BHP find additional mitigation for the vessel emissions occurring in federal waters, the company has identified and is committing to the use of Wartsila (or equivalent) engines in the tugs. This commitment has a substantial impact on the emissions attributable to the tugs. Although the low amount of tug traffic that occurs in District waters means that this has relatively small impacts to the stationary source emission inventory, it does result in a reduction. This is reflected in the updated emissions inventory included with this letter. Because the majority of NOx emissions in Federal waters were attributable to the tugs, the primary impact of this commitment is to reduce NOx emissions in Federal waters by roughly 60 tons per year. BHP appreciates South Coast's recognition of this achievement.

Emissions Inventory Spreadsheets: As noted above, BHP is submitting with this letter a revised set of the emissions inventory spreadsheets. Each page identifies the revision date for easy reference. These sheets should replace the contents of Appendix A and Appendix C in their entirety.

Please do not hesitate to contact me if you have any questions.

Sincerely,

Thomas R. Wood

TRW:nh

cc: Renee Klimezak
Rick Abel
Kevin Wright

Attachments: Errata Sheet
Updated Emissions Inventory Spreadsheets (App. A & C)

ATTACHMENT 1
ERRATA SHEET DATED APRIL 7, 2006

Errata Sheet
BHP Billiton LNG International Inc.
Preconstruction Air Permit Application for Cabrillo Port
April 7, 2006

At the request of EPA, BHP Billiton LNG International Inc. (BHP) conducted a review of the air quality permit application submitted to EPA Region 9 in December 2005. EPA had queried several points in the application and requested that BHP review the document and submit an Errata report identifying any changes or corrections. Based on this review, BHP has identified the following corrections to the application:

1.) Appendix A of the application contains the emission calculation spreadsheets. Appendix A, Tables FW 1 and DW 1 incorrectly identify the pilot fuel used when burning natural gas as "biodiesel." The pilot fuel is correctly identified as "diesel." In response to updated information about the tug engines, BHP has prepared new emissions calculations spreadsheets that reflect this correction.

2.) Diesel Storage Tank Capacity: The diesel tank capacity was identified as 144,500 gallons in the text of the application but appeared as slightly different values in the emissions inventory spreadsheets. The correct storage capacity is 144,500 gallons. The new emissions calculations spreadsheets have been revised to reflect this value consistently.

3.) Diesel Usage: While not an error in the application, BHP wanted to clarify that the Wartsila generator engines require limited time operating solely on diesel in order to periodically test the four engines for emergency preparedness purposes and to allow limited operation if the gas supply were interrupted. Total operations will not exceed the equivalent of firing one engine at full load for 100 hours per year. This equates to a maximum of 48,417 gallons of diesel per year for operation of the engines solely on diesel. This is separate from the diesel used as pilot fuel when the engines are operating on gas. BHP believes that it will be more straightforward to track the operation of the engines solely on diesel by monitoring the gallons of fuel used per year in that mode.

4.) Crew Boat Trips: In the application, BHP states at pages 3-4 and 3-5 that "The crewboat will conduct approximately 2.5 round trips per week." The correct number of projected crewboat trips is 182 round trips per year or 3.5 round trips per week. This is accurately reflected in the new emissions calculations spreadsheets.

5.) Material Handling Crane: In the application, BHP states at page 2-10 that the material handling crane will be diesel fired, while at 3-4 it is stated that the material handling crane will be electric. The material handling crane will be electric (or electro-hydraulic), not diesel fired.

ATTACHMENT 2
REVISED APPENDIX A

The Appendix A denoted "Revised 4/6/06" should replace the Appendix A in the December 2005 Minor New Source Review Construction Permit Application in its entirety.

Operating Emissions Summary

Stationary Source (FSRU)									
Qty.	Description	Rating (each)	Fuel	Annual Emissions, tons per year					
				NO_X	ROC	CO	SO_2	PM_{10}	CO_2	NH_3
3	Wartsila 9L50DF Main Generators	8250 KW	Gas / CA Diesel	12.2	24.5	20.8	0.1	8.1	54,279	6.0
1	Wartsila 9L50DF Backup Generator	8250 KW	Gas / CA Diesel	1.9	0.3	0.2	0.0	0.1	473	0.0
8	Sub-X Submerged Combustion Vaporizers	115 mmBTU/hr	Gas Only	48.9	3.5	148.9	0.3	3.8	215,271	-
4	Emergency Fire Pump / Generator	600 / 4200 KW	CA Diesel	3.0	0.4	1.9	0.0	0.1	370	-
1	Freefall Lifeboat	56 KW	CA Diesel	0.0	0.0	0.0	0.0	0.0	2	-
1	Diesel Fuel Storage Tank	144,500 gallons	CA Diesel	-	0.0	-	-	-	-	-
Total Emissions - Stationary Source (FSRU)				**66.1**	**28.7**	**171.7**	**0.42**	**12.1**	**270,395**	**6.1**

Vessels in Federal Waters									
Qty.	Description	Rating (each)	Fuel	Annual Emissions, tons per year					
				NO_X	ROC	CO	SO_2	PM_{10}	CO_2	NH_3
2	Tug Supply Boat	15,000 BHP Mains	Gas / CA Diesel	33.3	12.7	47.1	0.0	1.6	11,476	-
1	Crew Boat	1,500 BHP Mains	Gas Only	1.5	0.3	1.4	0.0	0.0	278	-
1	LNG Carrier	60,000 BHP Total	Gas / CA Diesel	61.9	8.4	40.0	0.0	0.8	7,893	-
Total Emissions - Vessel in Federal Waters				**96.7**	**21.4**	**88.5**	**0.03**	**2.4**	**19,648**	**-**

Vessels in District (State) Waters									
Qty.	Description	Rating (each)	Fuel	Annual Emissions, tons per year					
				NO_X	ROC	CO	SO_2	PM_{10}	CO_2	NH_3
2	Tug Supply Boat	15,000 BHP Mains	Gas / CA Diesel	0.26	0.10	0.37	0.00	0.01	92	-
1	Crew Boat	1,500 BHP Mains	Gas Only	0.31	0.06	0.29	0.00	0.01	57	-
Total Emissions - Vessel in District (State) Waters				**0.57**	**0.16**	**0.66**	**0.00**	**0.02**	**148**	**-**

All Project Elements							
Total Emissions - All Project Elements	NO_X	ROC	CO	SO_2	PM_{10}	CO_2	NH_3
Tons per Year	163.3	50.3	260.9	0.449	14.5	290,191	6.1
Tons per Day	0.45	0.14	0.71	0.001	0.04	795	0.02
Pounds per Day	895	275	1,430	2.5	79.5	n/a	33.2

Revised 4/6/06

Table FSRU 1: SCV and ICE Fuel Usage

Quantity	Description	Rating (each)	LNG Fuel Usage			
			mmBTU/hr	mcf/hr	hrs/yr	mmcf/yr
3	Wartsila 9L50DF Main Generators	8250 KW	100.21	99.45	8760	871
8	Sub-X Submerged Combustion Vaporizers	115 mmBTU/hr	460.00	456.53	8760	3,999
Total Usage			**560.21**	**555.98**		**4,870**
Total LNG Throughput (see notes)						**292,000**
Percent of Total Usage						**1.67%**

Device Notes:

FSRU throughput 800 mmcf/day, 365 days/yr, 292 mmmcf/yr total

Three 9L50DF main generators (8.25 MW each) operating at 100% load for hourly max, 110,903 MW-hr annual total, 99.4% gas fuel, 0.6% diesel pilot fuel (heat input)

Four SCVs operating at 100% capacity factor for 8,760 hrs/yr, low-NOx burners

Revised 4/6/06

Table FSRU 2: Equipment Controlled Emissions Summary

Quantity	Description	Rating (each)	Fuel	Annual Emissions, tons per year						
				NO_X	ROC	CO	SO_2	PM_{10}	CO_2	NH_3
3	Wartsila 9L50DF Main Generators	8250 KW	Gas / CA Diesel	12.2	24.5	20.8	0.08	8.1	54,279	6.01
1	Wartsila 9L50DF Backup Generator	8250 KW	Gas / CA Diesel	1.9	0.3	0.2	0.01	0.1	473	0.05
8	Sub-X Submerged Combustion Vaporizers	115 mmBTU/hr	Natural Gas	48.9	3.5	148.9	0.33	3.8	215,271	-
2	Emergency Fire Pump / Generator	600 / 4200 KW	CA Diesel	3.0	0.4	1.9	0.00	0.1	370	-
1	Freefall Lifeboat	56 KW	CA Diesel	0.0	0.0	0.0	0.00	0.0	2	-
1	Diesel Fuel Storage Tank	144,500 gallons	CA Diesel	-	0.03	-	-	-	-	-
Total Emissions				**66.1**	**28.7**	**171.7**	**0.42**	**12.1**	**270,395**	**6.06**

Device Notes:

FSRU throughput 800 mmcf/day, 365 days/yr, 292 mmmcf/yr total

Three 9L50DF main generators (8.25 MW each) operating at 100% load for hourly max, 110,903 MW-hr annual total, 99.4% gas fuel, 0.6% diesel pilot fuel (heat input)

Backup 9L50DF generator operating at 100% load for 100 machine hours per year, diesel fuel, 2006 Tier 2 standards

Four SCVs operating at 100% capacity factor for 8,760 hrs/yr, low-NOx burners

Emergency fire pump and generator operating at 100% load for 100 machine hours each per year, diesel fuel, 2006 Tier 2 standards

Three Life Boats exercising at 100% load for 50 machine hours per year total, diesel fuel, 2006 Tier 2 standards

Diesel Storage Tank, 144,500 gallon capacity, throughput based on diesel fuel usage defined above for applicable devices

Table FSRU 3: Equipment Uncontrolled Emissions Summary

Quantity	Description	Rating (each)	Fuel	Annual Emissions, tons per year						
				NO_X	ROC	CO	SO_2	PM_{10}	CO_2	NH_3
3	Wartsila 9L50DF Main Generators	8250 KW	Gas / CA Diesel	183.4	52.7	129.6	0.1	8.1	54,279	-
1	Wartsila 9L50DF Backup Generator	8250 KW	Gas / CA Diesel	13.4	0.6	0.9	0.0	0.1	473	-
8	Sub-X Submerged Combustion Vaporizers	115 mmBTU/hr	Natural Gas	97.9	3.5	119.1	0.3	3.8	215,271	-
2	Emergency Fire Pump / Generator	600 / 4200 KW	CA Diesel	3.0	0.4	1.9	0.0	0.1	370	-
1	Freefall Lifeboat	56 KW	CA Diesel	0.0	0.0	0.0	0.0	0.0	2	-
1	Diesel Fuel Storage Tank	144,500 gallons	CA Diesel	-	0.03	-	-	-	-	-
Total Emissions				**297.6**	**57.2**	**251.5**	**0.4**	**12.1**	**270,395**	**-**

Device Notes:

FSRU throughput 800 mmcf/day, 365 days/yr, 292 mmmcf/yr total

Three 9L50DF main generators (8.25 MW each) operating at 100% load for hourly max, 110,903 MW-hr annual total, 99.4% gas fuel, 0.6% diesel pilot fuel (heat input)

Backup 9L50DF generator operating at 100% load for 100 machine hours per year, diesel fuel, 2006 Tier 2 standards

Four SCVs operating at 100% capacity factor for 8,760 hrs/yr, low-NOx burners

Emergency fire pump and generator operating at 100% load for 100 machine hours each per year, diesel fuel, 2006 Tier 2 standards

Three Life Boats exercising at 100% load for 50 machine hours per year total, diesel fuel, 2006 Tier 2 standards

Diesel Storage Tank, 144,500 gallon capacity, throughput based on diesel fuel usage defined above for applicable devices

Table FSRU 4: Release Parameters

Release Parameter	Units	Main Gens	Backup Gen	Vaporizers	Emerg. Pump	Emerg. Gen	Life Boat
Fuel	Type	Dual Fuel	Diesel	Gas	Diesel	Diesel	Diesel
Heat Input	mmBTU/hr	197.1	66.3	460.0	5.9	35.8	0.64
Wet Fd Factor	wscf/mmBTU	10,608	10,320	10,610	10,320	10,320	10,320
Oxygen Content	percent	15%	15%	3%	15%	15%	15%
Exhaust Temperature	Deg F	800	800	70	800	800	800
Stack Diameter	inches	68.2	39.4	78.7	10.0	26.0	3.0
Stack Area	sq. ft.	25.36	8.45	33.82	0.55	3.69	0.05
Stack Flow	wscf/min	123,434	40,424	94,976	3,565	21,835	388
Stack Flow	wacf/min	294,558	96,467	95,336	8,507	52,106	926
Stack Velocity	ft/min	11,614	11,411	2,819	15,597	14,132	18,871
Release Height	meters	33	33	35	25	25	1
Release Diameter	meters	1.73	1.00	2.00	0.25	0.66	0.08
Release Velocity	meters/sec	59.0	58.0	14.3	79.2	71.8	95.9
Release Temperature	degrees K	700	700	294	700	700	700

Downwash Dimensions	Units	FSRU Hull
Height	meters	21
Width (min horizontal)	meters	65
Length (max horizontal)	meters	286

Revised 4/6/06

Table FSRU 5: Wartsila 9L50DF Controlled Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Dual Fuel ICE generator, Wartsila 50DF		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S (with 0.6% diesel pilot charge, 15 ppmw S)		
TOTAL YEARLY PROCESS RATE	110903	MW-hrs	from BHP estimates
HOURLY PROCESS RATE	24.75	MW	from BHP estimates
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cf	Scarborough LNG specification
OPERATING SCHEDULE	8760	hrs/yr	
HEAT RATE	7963	BTU/KW-hr	Wartsila Spec 0047057-S504, 13 May 05, corrected to HHV (110% of LHV)
CONVERSION EFFICIENCY	42.9%	percent	
HEAT INPUT	197.08	mmBTU/hr	HHV correction applies
DRY Fd	8713	dscf/mmBTU	USEPA Method 19, corrected for 0.6% diesel pilot fuel heat input
EXHAUST FLOW	6.08	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	7.514	1.0000	0.2205	24,450	12.23	5.46	0.100	0.075
Reactive Hydrocarbons (ROC) as CH_4	43.2	1.0000	0.4409	48,900	24.45	10.91	0.200	0.149
Carbon Monoxide (CO)	21.0	1.0000	0.3748	41,565	20.78	9.28	0.170	0.127
Sulfur Dioxide (SO_2)	0.034	1.0484	0.0014	153	0.08	0.03	0.0006	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0042	1.0000	0.1459	16,186	8.09	3.61	0.0662	0.049
Carbon Dioxide (CO_2)	3.49%	1.0000	978.8576	108,558,240	54,279	24,227	444	331
Ammonia Slip (NH_3)	10	1.0000	0.1084	12,026	6.01	2.68	0.049	0.037

Wartsila Emission Factors (BACT)

NO_X = 0.10 g/kw-hr (Wartsila Specification 16 March 2006)

VOC = 0.20 g/kw-hr (Wartsila Specification 16 March 2006)

CO = 0.17 g/kw-hr (Wartsila Specification 16 March 2006)

PM_{10} = 0.0662 g/kw-hr (Wartsila Specification 16 March 2006)

CO_2 = 444 g/kw-hr (Wartsila Report 4 July 2003)

Pilot Diesel Fuel Usage	38,668	gal/yr

Average generation	110,903	MW-hrs/yr
Maximum generation	216,810	MW-hrs/yr
Average Capacity Factor	51.2%	percent

Revised 4/6/06

Table FSRU 6: Wartsila 9L50DF Uncontrolled Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Dual Fuel ICE generator, Wartsila 50DF		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S (with 0.6% diesel pilot charge, 15 ppmw S)		
TOTAL YEARLY PROCESS RATE	110903	MW-hrs	from BHP estimates
HOURLY PROCESS RATE	24.75	MW	from BHP estimates
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cf	Scarborough LNG specification
OPERATING SCHEDULE	8760	hrs/yr	
HEAT RATE	7963	BTU/KW-hr	Wartsila Spec 0047057-S504, 13 May 05, corrected to HHV (110% of LHV)
CONVERSION EFFICIENCY	42.9%	percent	
HEAT INPUT	197.08	mmBTU/hr	HHV correction applies
DRY Fd	8713	dscf/mmBTU	USEPA Method 19, corrected for 0.6% diesel pilot fuel heat input
EXHAUST FLOW	6.08	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	112.7	1.0000	3.3070	366,751	183.38	81.85	1.500	1.119
Reactive Hydrocarbons (ROC) as CH_4	93.1	1.0000	0.9502	105,380	52.69	23.52	0.431	0.321
Carbon Monoxide (CO)	130.8	1.0000	2.3369	259,171	129.59	57.84	1.060	0.790
Sulfur Dioxide (SO_2)	0.034	1.0484	0.0014	153	0.08	0.03	0.0006	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0042	1.0000	0.1459	16,186	8.09	3.61	0.0662	0.049
Carbon Dioxide (CO_2)	3.49%	1.0000	978.8576	108,558,240	54,279	24,227	444	331
Ammonia Slip (NH_3)								

Wartsila Emission Factors (Uncontrolled)

NO_X = 1.50 g/kw-hr (Wartsila Specification 16 March 2006)

VOC = 0.431 g/kw-hr (Wartsila Specification 16 March 2006)

CO = 1.06 g/kw-hr (Wartsila Specification 16 March 2006)

PM_{10} = 0.0662 g/kw-hr (Wartsila Specification 16 March 2006)

CO_2 = 444 g/kw-hr (Wartsila Report 4 July 2003)

Revised 4/6/06

Table FSRU 7: Wartsila 9L50DF Diesel Emissions Controlled Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Dual Fuel ICE generator, Wartsila 50DF		
FUEL TYPE/PROCESS INFO	California diesel, 15 ppmw S		
TOTAL YEARLY PROCESS RATE	825	MW-hrs	
HOURLY PROCESS RATE	8.25	MW	from BHP estimates
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	137030	BTU/gal	USEPA AP-42
OPERATING SCHEDULE	100	hrs/yr	
HEAT RATE	8042	BTU/KW-hr	Wartsila Spec 0047057-S504, 13 May 05
CONVERSION EFFICIENCY	42.4%	percent	
HEAT INPUT	66.35	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	2.16	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	150	1.0000	4.6884	3,868	1.93	38.68	2.127	1.586
Reactive Hydrocarbons (ROC) as CH_4	60	1.0000	0.6523	538	0.27	5.38	0.296	0.221
Carbon Monoxide (CO)	25	1.0000	0.4756	392	0.20	3.92	0.216	0.161
Sulfur Dioxide (SO_2)	0.29	1.0000	0.013	10	0.01	0.10	0.006	0.004
Particulates (as PM_{10}) (grains/dscf)	0.0091	1.0000	0.3395	280	0.14	2.80	0.154	0.115
Carbon Dioxide (CO_2)	3.83%	1.0000	1146.4098	945,788	473	9,458	520	388
Ammonia Slip (NH_3)	10	1.0000	0.1155	95	0.05	0.95	0.052	0.039

Wartsila Emission Factors (Controlled)

NO_X = 150 ppm, 2.127 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

VOC = 60 ppm, 0.296 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

CO = 25 ppm, 0.216 g/kw-hr (Wartsila Spec Spec 0047057-S504, 13 May 05)

PM_{10} = 0.154 g/kw-hr (Wartsila Specification 16 March 2006)

CO_2 = 520 g/kw-hr (Wartsila)

Revised 4/6/06

Table FSRU 8: Wartsila 9L50DF Diesel Emissions Uncontrolled Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Dual Fuel ICE generator, Wartsila 50DF		
FUEL TYPE/PROCESS INFO	California diesel, 15 ppmw S		
TOTAL YEARLY PROCESS RATE	825	MW-hrs	
HOURLY PROCESS RATE	8.25	MW	from BHP estimates
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	137030	BTU/gal	USEPA AP-42
OPERATING SCHEDULE	100	hrs/yr	
HEAT RATE	8042	BTU/KW-hr	Wartsila Spec 0047057-S504, 13 May 05
CONVERSION EFFICIENCY	42.4%	percent	
HEAT INPUT	66.35	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	2.16	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	1037	1.0000	32.4081	26,737	13.37	267.37	14.700	10.962
Reactive Hydrocarbons (ROC) as CH_4	132	1.0000	1.4352	1,184	0.59	11.84	0.651	0.485
Carbon Monoxide (CO)	119	1.0000	2.2708	1,873	0.94	18.73	1.030	0.768
Sulfur Dioxide (SO_2)	0.3	1.0000	0.0125	10	0.01	0.10	0.006	0.004
Particulates (as PM_{10}) (grains/dscf)	0.0091	1.0000	0.3395	280	0.14	2.80	0.154	0.115
Carbon Dioxide (CO_2)	3.83%	1.0000	1146.4098	945,788	473	9,458	520	388
Ammonia Slip (NH_3)								

Wartsila Emission Factors (Uncontrolled)

NO_X = 14.70 g/kw-hr (Wartsila Specification 16 March 2006)

VOC = 0.651 g/kw-hr (Wartsila Specification 16 March 2006)

CO = 1.03 g/kw-hr (Wartsila Specification 16 March 2006)

PM_{10} = 0.154 g/kw-hr (Wartsila Specification 16 March 2006)

CO_2 = 520 g/kw-hr (Wartsila)

Table FSRU 9: SCV Controlled Emissions Summary

SIC	1321	
PROCESS EQPT DESCRIPTION	Submerged Combustion Vaporizer, Selas Sub-X, 120-180 ton LNG/hr, Low NO_X Burner	
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S	
TOTAL YEARLY PROCESS RATE	3999.206	
HOURLY PROCESS RATE	0.456530	
PROCESS UNITS	PT074	Million Cubic Feet Burned
HIGHER HEATING VALUE	1007.6	mmBTU/mmcf
OPERATING SCHEDULE	8760	hrs/yr
NUMBER OF DEVICES	4.00	Average
UNIT RATING	115.000	mmBTU/hr
HEAT INPUT	460.00	mmBTU/hr
DRY Fd	8710	dscf/mmBTU USEPA Method 19
EXHAUST FLOW	4.68	mmdscf/hr

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE lb/mmBTU
Nitrogen Oxides (as NO_2)	20.0	1.0000	24.467	97,850	48.93	11.17	0.0243
Reactive Hydrocarbons (ROC) as CH_4	4.1	1.0000	1.745	6,977	3.49	0.80	0.0017
Carbon Monoxide (CO)	100.0	1.0000	74.466	297,805	148.90	34.00	0.0739
Sulfur Dioxide (SO_2)	0.10	1.0000	0.166	664	0.33	0.08	0.0002
Particulates (as PM_{10}) (grains/dscf)	0.0013	1.0000	1.900	7,598	3.80	0.87	0.0019
Carbon Dioxide (CO_2)	9.2%	1.0000	107656.700	430,541,325	215270.66	49148.55	106.8447
Ammonia Slip (NH_3)							

Emission Factors @ 3% oxygen

NO_X = 20 ppmv (Selas Specification)

ROC = 4.1 ppmv (Costain Report)

CO = 100 ppmv (Selas Specification)

PM_{10} = 1.9 lb/mmcf (AP-42 Table 1.4-2, non-condensible filterable fraction, condensibles remain in 70 F water solution)

CO_2 = 9.2% (Selas Specification, 6.6% @ 8% oxygen)

Device Notes:

FSRU throughput 800 mmcf/day, 365 days/yr, 292 mmmcf/yr total

SCV sendout rate =200 mmscf/day (guarantee)

Throughput, mmcf/day	800	design
SCV Sendout, mmcf/day each	200	guarantee
Equivalent SCVs Operating	4.00	average

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Table FSRU 10: SCV Uncontrolled Emissions Summary

SIC	1321	
PROCESS EQPT DESCRIPTION	Submerged Combustion Vaporizer, Selas Sub-X, 120-180 ton LNG/hr, Standard Burner	
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S	
TOTAL YEARLY PROCESS RATE	3999.206	
HOURLY PROCESS RATE	0.456530	
PROCESS UNITS	PT074	Million Cubic Feet Burned
HIGHER HEATING VALUE	1007.6	mmBTU/mmcf
OPERATING SCHEDULE	8760	hrs/yr
NUMBER OF DEVICES	4.00	Average
UNIT RATING	115.000	mmBTU/hr
HEAT INPUT	460.00	mmBTU/hr
DRY Fd	8710	dscf/mmBTU USEPA Method 19
EXHAUST FLOW	4.68	mmdscf/hr

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE lb/mmBTU
Nitrogen Oxides (as NO_2)	40.0	1.0000	48.935	195,701	97.85	22.34	0.0486
Reactive Hydrocarbons (ROC) as CH_4	4.1	1.0000	1.745	6,977	3.49	0.80	0.0017
Carbon Monoxide (CO)	80.0	1.0000	59.573	238,244	119.12	27.20	0.0591
Sulfur Dioxide (SO_2)	0.10	1.0000	0.166	664	0.33	0.08	0.0002
Particulates (as PM_{10}) (grains/dscf)	0.0013	1.0000	1.900	7,598	3.80	0.87	0.0019
Carbon Dioxide (CO_2)	9.2%	1.0000	107656.700	430,541,325	215270.66	49148.55	106.8447
Ammonia Slip (NH_3)							

Emission Factors @ 3% oxygen

NO_X = 40 ppmv (Selas Specification)

ROC = 4.1 ppmv (Costain Report)

CO = 80 ppmv (Selas Specification)

PM_{10} = 1.9 lb/mmcf (AP-42 Table 1.4-2, non-condensible filterable fraction, condensibles remain in 70 F water solution)

CO_2 = 9.2% (Selas Specification, 6.6% @ 8% oxygen)

Device Notes:

FSRU throughput 800 mmcf/day, 365 days/yr, 292 mmmcf/yr total

SCV sendout rate =200 mmscf/day (guarantee)

Throughput, mmcf/day	800	design
SCV Sendout, mmcf/day each	200	guarantee
Equivalent SCVs Operating	4.00	average

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Table FSRU 11: Firewater Pumps Emission Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Firewater Pump, 600 KW		
FUEL TYPE/PROCESS INFO	California diesel, 15 ppmw S		
TOTAL YEARLY PROCESS RATE	60	MW-hrs	
HOURLY PROCESS RATE	0.60	MW	from BHP estimates
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	137030	BTU/gal	USEPA AP-42
OPERATING SCHEDULE	100	hrs/yr	
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	5.85	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.19	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	326	1.0000	12.3460	741	0.37	7.41	5.600	4.176
Reactive Hydrocarbons (ROC) as CH_4	134	1.0000	1.7637	106	0.05	1.06	0.800	0.597
Carbon Monoxide (CO)	334	1.0000	7.7162	463	0.23	4.63	3.500	2.610
Sulfur Dioxide (SO_2)	0.3	1.0000	0.015	1	0.00	0.01	0.007	0.005
Particulates (as PM_{10}) (grains/dscf)	0.0097	1.0000	0.4409	26	0.01	0.26	0.200	0.149
Carbon Dioxide (CO_2)	4.26%	1.0000	1543.2439	92,595	46	926	700	522
Ammonia Slip (NH_3)								

* USEPA Tier 2 Standards (>560 kw)

NO_X + ROC = 6.4 g/kw-hr

CO = 3.5 g/kw-hr

PM_{10} = 0.2 g/kw-hr

CO_2 = 700 g/kw-hr (AP-42, Table 3.3-1)

Diesel Fuel Usage 4,270 gal/yr

Revised 4/6/06

Table FSRU 12: Emergency Generator Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Emergency Generator, 4200 KW		
FUEL TYPE/PROCESS INFO	California diesel, 15 ppmw S		
TOTAL YEARLY PROCESS RATE	420	MW-hrs	
HOURLY PROCESS RATE	4.20	MW	from BHP estimates
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	137030	BTU/gal	USEPA AP-42
OPERATING SCHEDULE	100	hrs/yr	
HEAT RATE	8533	BTU/KW-hr	
CONVERSION EFFICIENCY	40.0%	percent	
HEAT INPUT	35.84	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	1.17	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	372	1.0000	12.3460	5,185	2.59	51.85	5.600	4.176
Reactive Hydrocarbons (ROC) as CH_4	153	1.0000	1.7637	741	0.37	7.41	0.800	0.597
Carbon Monoxide (CO)	382	1.0000	7.7162	3,241	1.62	32.41	3.500	2.610
Sulfur Dioxide (SO_2)	0.3	1.0000	0.013	6	0.003	0.056	0.006	0.004
Particulates (as PM_{10}) (grains/dscf)	0.0111	1.0000	0.4409	185	0.09	1.85	0.200	0.149
Carbon Dioxide (CO_2)	4.87%	1.0000	1543.2439	648,162	324	6,482	700	522
Ammonia Slip (NH_3)								

* USEPA Tier 2 Standards (>560 kw)

NO_X + ROC = 6.4 g/kw-hr

CO = 3.5 g/kw-hr

PM_{10} = 0.2 g/kw-hr

CO_2 = 700 g/kw-hr (AP-42, Table 3.3-1)

Diesel Fuel Usage 26,152 gal/yr

Revised 4/6/06

Table FSRU 13: Freefall Lifeboat Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Freefall Lifeboat Engine, 75 BHP (56 KW)		
FUEL TYPE/PROCESS INFO	California diesel, 15 ppmw S		
TOTAL YEARLY PROCESS RATE	2.8	MW-hrs	
HOURLY PROCESS RATE	0.056	MW	from BHP estimates
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	137030	BTU/gal	USEPA AP-42
OPERATING SCHEDULE	50	hrs/yr	
HEAT RATE	11377	BTU/KW-hr	
CONVERSION EFFICIENCY	30.0%	percent	
HEAT INPUT	0.64	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.02	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	324	1.0000	14.3301	40	0.02	0.80	6.500	4.847
Reactive Hydrocarbons (ROC) as CH_4	143	1.0000	2.2046	6	0.00	0.12	1.000	0.746
Carbon Monoxide (CO)	410	1.0000	11.0232	31	0.02	0.62	5.000	3.729
Sulfur Dioxide (SO_2)	0.3	1.0000	0.018	0	0.00	0.00	0.008	0.006
Particulates (as PM_{10}) (grains/dscf)	0.0167	1.0000	0.8819	2	0.00	0.05	0.400	0.298
Carbon Dioxide (CO_2)	3.65%	1.0000	1543.2439	4,321	2	86	700	522

* USEPA Tier 2 Standards (>37 kw, <75 kw)

NO_X + ROC = 7.5 g/kw-hr

CO = 5.0 g/kw-hr

PM_{10} = 0.4 g/kw-hr

CO_2 = 700 g/kw-hr (AP-42, Table 3.3-1)

Diesel Fuel Usage 232 gal/yr

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Table FSRU 14: Diesel Storage Tank Emissions Summary

SIC	1321	
PROCESS EQPT DESCRIPTION	Standby Diesel Fuel Storage Tank, 144,500 gallon	
FUEL TYPE/PROCESS INFO	Rule 431.2 California Diesel, 15 ppmw S	
TOTAL YEARLY PROCESS RATE	117.740	
AVERAGE HOURLY PROCESS RATE	0.013	
MAXIMUM HOURLY PROCESS RATE	0.013	
PROCESS UNITS	PT031	1000 GALLONS THROUGHPUT
HIGHER HEATING VALUE	137.03	mmBTU/mgal
NUMBER OF DEVICES	1	
HRS/YEAR	8760	
TOTAL YEARLY PROCESS RATE	59.7	
AVERAGE HOURLY PROCESS RATE	0.0068	
MAXIMUM HOURLY PROCESS RATE	0.0068	
PROCESS UNITS	PT079	POUNDS (VOC)

EMITTENT NAME	EMITTENT PPMV		CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR
Nitrogen Oxides (as NO_2)						
Reactive Hydrocarbons (ROC) as CH_4			1.0	59.7	0.030	0.0068
Carbon Monoxide (CO)						
Sulfur Dioxide (SO_2)						
Particulates (as PM_{10}) (grains/dscf)						
Carbon Dioxide (CO_2)						
Ammonia Slip (NH_3)						
Benzene			0.00088	0.05	0.000	0.000
Toluene			0.00482	0.29	0.000	0.000
Xylenes			0.00420	0.25	0.000	0.000

HAP speciation SJVUAPCD 7/14/95

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Table FSRU 14: Diesel Storage Tank Emissions Summary

SCAQMD AP-42 Fixed Roof Eqns.	Value	Units	
Number of Tanks	1		
Tank Diameter, D	40.000	ft	
Shell Height, Hs	15.380	ft	
Vapor Outage Headspace, Hvo	7.690	ft	
Tank Capacity, C	3442.300	bbl	
Throughput, Q	2803	bbl/yr	117,740 gal/yr
Turnovers, N	0.814	#/yr	
True Vapor Pressure, P	0.009	psia	
Vapor Molecular Weight, Mv	130	lb/lb-mole	
Storage Temperature, Ts	65	F	
Delta Temp, Tv	25	F	
Paint Alpha, a	0.1700	a	
Product Factor, Kp	1.0000		
Vapor Space Volume, Vv	9663.5390	ft3	
Vapor Density, Wv	0.0002	lb/ft3	
Vapor Space Expansion Factor, Ke	0.0352		
Vapor Saturation Factor, Kv	0.9963		
Turnover Factor, Kn	1.0000		
Beathing Loss, Lb	25.6641	lb/yr	
Working Loss, Lw	3.2799	lb/yr	
Total Tank Losses, Lt	28.9440	lb/yr	

Fugitive Components	lb/yr	EF, lb/hr	Count
Valves, Gas	0.0000	0.012	
Valves, Light Liquid	0.0000	0.016	
Valves, Heavy Liquid	67.0140	0.00051	15
Flanges, General	31.5360	0.0018	2
Pump Seals, Light Liquid	0.0000	0.11	
Pump Seals, Heavy Liquid	823.4400	0.047	2
Pressure Relief Valves	0.0000	0.23	
Low Pressure Correction Factor	0.0333		
Total Fugitive Losses, Lf	30.7238		

Total Emissions, Et	59.6678	lb/yr

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Index: District Waters Vessel Emission Summary Tables

Table DW 1: District Waters Vessel Emissions Summary

Quantity	Description	Rating (each)	Fuel	Annual Emissions, tons per year					
				NO_X	ROC	CO	SO_2	PM_{10}	CO_2
2	Tug Supply Boat	15,000 BHP Mains	Gasified LNG & CA Diesel	0.26	0.10	0.37	0.000	0.01	92
1	Crew Boat	1,500 BHP Mains	Gasified LNG	0.31	0.06	0.29	0.000	0.01	57
Total Emissions (gasified LNG & CA diesel pilot fuel)				**0.57**	**0.16**	**0.66**	**0.000**	**0.02**	**148**

Vessel Notes:

Tug Supply boat making 52 round trips to FSRU per year, time & load weighted engine operation

Crew boat making 182 round trips to FSRU per year, time & load weighted engine operation

Operating component in state waters only (inside 3-mile limit)

Tug Supply dual fuel is 99% gasified LNG / 1% CA diesel by weight (99.2% / 0.8% by heat input)

Crew boat is 100% gasified LNG

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Table DW 2: Tug/ Supply Vessel Main Engine Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Tug Supply Main Generator Set Engines, 15,000 BHP, 2 vessels alternating port calls		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S & 15 ppmw S California diesel pilot charge		
TOTAL YEARLY PROCESS RATE	174	MW-hrs	
HOURLY PROCESS RATE	3.36	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/scf	
COMBINED ENGINE RATING	15000	BHP	from BHP estimates
LOAD FACTOR	30%	percent	from activity profile
OPERATING SCHEDULE	52	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	32.72	mmBTU/hr	
DRY Fd	8710	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	1.010	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	80	1.0000	2.8660	500	0.250	9.618	1.300	0.969
Reactive Hydrocarbons (ROC) as CH_4	92	1.0000	1.1464	200	0.100	3.847	0.520	0.388
Carbon Monoxide (CO)	192	1.0000	4.1888	731	0.365	14.056	1.900	1.417
Sulfur Dioxide (SO_2)	0.03	1.0654	0.0017	0	0.000	0.006	0.0008	0.0006
Particulates (as PM_{10}) (grains/dscf)	0.0033	1.0000	0.1433	25	0.013	0.481	0.065	0.048
Carbon Dioxide (CO_2)	3.00%	1.0000	1031.7688	180,040	90.020	3462.311	468	349

Wartsila Emission Factors for Series 32DF Engines

NO_X = 1.3 g/kw-hr (Wartsila Specification 16 March 2006)

VOC = 0.52 g/kw-hr (Warsila Report Specification 16 March 2006, corrected to 8% nonmethane per AP-42 Table 3.2-2)

CO = 1.9 g/kw-hr (Wartsila Specification 16 March 2006)

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S)

PM_{10} = 0.065 g/kw-hr (Wartsila quote 16 February 2006)

CO_2 = 468 g/kw-hr (Wartsila Report 4 July 2003)

Tug Supply dual fuel is 99% gasified LNG / 1% CA diesel by weight (99.2% / 0.8% by heat input)

Power output 234,000 BHP-hr/yr

Revised 4/6/06

Table DW 3: Tug/Supply Vessel Generator Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Tug Supply Auxiliary Generator, 150 BHP, 2 vessels alternating port calls		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S		
TOTAL YEARLY PROCESS RATE	3	MW-hrs	
HOURLY PROCESS RATE	0.06	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/scf	
COMBINED ENGINE RATING	150	BHP	from BHP estimates
LOAD FACTOR	50%	percent	from activity profile
OPERATING SCHEDULE	52	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	0.55	mmBTU/hr	
DRY Fd	8710	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.017	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	165	1.0000	5.9128	17	0.009	0.331	2.682	2.000
Reactive Hydrocarbons (ROC) as CH_4	92	1.0000	1.1507	3	0.002	0.064	0.522	0.389
Carbon Monoxide (CO)	248	1.0000	5.4315	16	0.008	0.304	2.464	1.837
Sulfur Dioxide (SO_2)	0.03	1.0000	0.0016	0	0.000	0.000	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0023	1.0000	0.0975	0	0.000	0.005	0.044	0.033
Carbon Dioxide (CO_2)	3.12%	1.0000	1072.6571	3,120	1.560	59.992	487	363

Gas Emission Factors (AP-42 Table 3.2-2)

NO_X = 2.682 g/kw-hr (CAT Series GLE Engines 2.0 g/bhp-hr)

VOC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

Revised 4/6/06

Table DW 4: Tug/Supply Vessel Activity Summary

Tug Supply

District Waters Transit	Miles	Speed	Time, hrs	Mains	Weighted	Mode
Engine start & idle at dock	0	0	0.12	10%	1.2%	4.0%
Transit harbor zone outbound	0.75	5	0.15	14%	2.1%	7.0%
Due south to boundary	3.5	18.5	0.19	51%	9.7%	32.1%
Federal Waters						
Due north from boundary	3.5	18.5	0.19	51%	9.7%	32.1%
Transit harbor zone inbound	0.75	5	0.15	14%	2.1%	7.0%
Docking & engine stop	0	0	0.20	27%	5.4%	17.9%
Composite			**1.00**		**30%**	**100%**

Cruising in District waters per week **0.38**

Remarks - District Waters Transit

1 roundtrip/week = 52 roundtrips/year
52 trips/yr x 1 hr/trip = 52 hrs/yr @ 30% power on mains
ship generators run all the time, so
52 trips/yr x 1 hrs/trip = 52 hrs/yr @ 50% power

Start/Stop/Idle	21.9%
Harbor Transit	14.0%
Cruise to/from Boundary	64.1%
	100.0%

Table DW 5: Crew Boat Main Engine Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Crew Boat Main Engines, 1500 BHP		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S		
TOTAL YEARLY PROCESS RATE	96	MW-hrs	
HOURLY PROCESS RATE	0.53	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/scf	
COMBINED ENGINE RATING	1500	BHP	from BHP estimates
LOAD FACTOR	47%	percent	from activity profile
OPERATING SCHEDULE	182	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	5.13	mmBTU/hr	
DRY Fd	8710	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.158	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	165	1.0000	5.9128	566	0.283	3.109	2.682	2.000
Reactive Hydrocarbons (ROC) as CH_4	92	1.0000	1.1507	110	0.055	0.605	0.522	0.389
Carbon Monoxide (CO)	248	1.0000	5.4315	520	0.260	2.856	2.464	1.837
Sulfur Dioxide (SO_2)	0.03	1.0000	0.0016	0	0.000	0.001	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0023	1.0000	0.0975	9	0.005	0.051	0.044	0.033
Carbon Dioxide (CO_2)	3.12%	1.0000	1072.6571	102,634	51.317	563.925	487	363

Gas Emission Factors (AP-42 Table 3.2-2)

NO_X = 2.682 g/kw-hr (CAT Series GLE Engines 2.0 g/bhp-hr)

VOC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

Revised 4/6/06

Table DW 6: Crew Boat Generator Engine Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Crew Boat Generator Engine, 150 BHP		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S		
TOTAL YEARLY PROCESS RATE	10	MW-hrs	
HOURLY PROCESS RATE	0.06	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/scf	
COMBINED ENGINE RATING	150	BHP	from BHP estimates
LOAD FACTOR	50%	percent	from activity profile
OPERATING SCHEDULE	182	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	0.55	mmBTU/hr	
DRY Fd	8710	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.017	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	165	1.0000	5.9128	60	0.030	0.331	2.682	2.000
Reactive Hydrocarbons (ROC) as CH_4	92	1.0000	1.1507	12	0.006	0.064	0.522	0.389
Carbon Monoxide (CO)	248	1.0000	5.4315	55	0.028	0.304	2.464	1.837
Sulfur Dioxide (SO_2)	0.03	1.0000	0.0016	0	0.000	0.000	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0023	1.0000	0.0975	1	0.000	0.005	0.044	0.033
Carbon Dioxide (CO_2)	3.12%	1.0000	1072.6571	10,919	5.459	59.992	487	363

Gas Emission Factors (AP-42 Table 3.2-2)

NO_X = 2.682 g/kw-hr (CAT Series GLE Engines 2.0 g/bhp-hr)

VOC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

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Table DW 7: Crew Boat Activity Summary

Crew Boats

District Waters Transit	Miles	Speed	Time, hrs	Mains Weighted		Mode
Engine start & idle at dock	0	0	0.12	13%	1.6%	3.3%
Transit harbor zone outbound	0.75	5	0.15	24%	3.6%	7.7%
Due south to boundary	3.5	18.5	0.19	90%	17.1%	36.5%
Federal Waters						
Due north from boundary	3.5	18.5	0.19	90%	17.1%	36.5%
Transit harbor zone inbound	0.75	5	0.15	24%	3.6%	7.7%
Docking & engine stop	0	0	0.20	19%	3.8%	8.2%
District waters composite per trip			**1.00**		**47%**	**100%**

Cruising in District waters per week **1.32**

Remarks - District Waters Transit

1 roundtrip/berthing = 2.5 per week + 1 crew change/week = 3.5 roundtrips/week or 182 roundtrips/year
182 trips/yr x 1 hr/trip = 182 hrs/yr @ 47% power on mains
ship generators run all the time, so
182 trips/yr x 1 hrs/trip = 182 hrs/yr @ 50% power

Start/Stop/Idle	11.5%
Harbor Transit	15.4%
Cruise to/from Boundary	73.1%
	100.0%

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Index: Federal Waters Vessel Emission Summary Tables

Table FW 1: Federal Waters Vessels Emission Summary

Quantity	Description	Rating (each)	Fuel	Annual Emissions, tons per year					
				NO_X	ROC	CO	SO_2	PM_{10}	CO_2
2	Tug Supply Boat	15,000 BHP Mains	Gasified LNG & CA Diesel	33.3	12.7	47.1	0.02	1.6	11,476
1	Crew Boat	1,500 BHP Mains	Gasified LNG	1.5	0.3	1.4	0.00	0.0	278
1	LNG Carrier	60,000 BHP Total	Gasified LNG & CA Diesel	61.9	8.4	40.0	0.01	0.8	7,893
Total Emissions (gasified LNG & CA diesel pilot fuel)				**96.7**	**21.4**	**88.5**	**0.03**	**2.4**	**19,648**

Vessel Notes:

Assist tugs (pair) conducting LNG carrier to FSRU berthing operations 130 times per year, time & load weighted engine operation

Tug Supply boat making 52 round trips to FSRU per year, time & load weighted engine operation

Crew boat making 182 round trips to FSRU per year, time & load weighted engine operation

LNG carrier to FSRU berthing operations, 14 miles slow, 3 miles to FSRU with assist tugs, time & load weighted engine operation

Operating component in federal waters only (outside 3-mile limit)

LNG Carrier & Tug Supply dual fuel is 99% gasified LNG / 1% CA diesel by weight (99.2% / 0.8% by heat input)

Crew boat is 100% gasified LNG

Table FW 2: Tug/Supply Vessel Main Engine Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Tug Supply Main Generator Set Engines, 15,000 BHP, 2 vessels alternating port calls		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S & 15 ppmw S California diesel pilot charge		
TOTAL YEARLY PROCESS RATE	21242	MW-hrs	
HOURLY PROCESS RATE	1.23	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	15000	BHP	from BHP estimates
LOAD FACTOR	11%	percent	from activity profile
OPERATING SCHEDULE	17264	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	12.00	mmBTU/hr	
DRY Fd	8710	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.37	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	2 Vessels ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	80	1.0000	2.8660	60,880	30.44	7.05	1.300	0.969
Reactive Hydrocarbons (ROC) as CH_4	92	1.0000	1.1464	24,352	12.18	2.82	0.520	0.388
Carbon Monoxide (CO)	192	1.0000	4.1888	88,979	44.49	10.31	1.900	1.417
Sulfur Dioxide (SO_2)	0.03	1.0654	0.0017	36	0.02	0.00	0.0008	0.0006
Particulates (as PM_{10}) (grains/dscf)	0.0033	1.0000	0.1433	3,044	1.52	0.35	0.065	0.048
Carbon Dioxide (CO_2)	3.00%	1.0000	1031.7688	21,916,892	10,958	2,539	468	349

Wartsila Emission Factors for Series 32DF Engines

NO_X = 1.3 g/kw-hr (Wartsila Specification 16 March 2006)

VOC = 0.52 g/kw-hr (Warsila Report Specification 16 March 2006, corrected to 8% nonmethane per AP-42 Table 3.2-2)

CO = 1.9 g/kw-hr (Wartsila Specification 16 March 2006)

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S)

PM_{10} = 0.065 g/kw-hr (Wartsila quote 16 February 2006)

CO_2 = 468 g/kw-hr (Wartsila Report 4 July 2003)

Tug Supply dual fuel is 99% gasified LNG / 1% CA diesel by weight (99.2% / 0.8% by heat input)

Power output 28,485,600 BHP-hr/yr

Revised 4/6/06

Table FW 3: Tug/Supply Vessel Generator Engines Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Tug Supply Auxiliary Generator, 150 BHP, 2 vessels alternating port calls		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S		
TOTAL YEARLY PROCESS RATE	966	MW-hrs	
HOURLY PROCESS RATE	0.06	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	150	BHP	from BHP estimates
LOAD FACTOR	50%	percent	from activity profile
OPERATING SCHEDULE	17264	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	0.55	mmBTU/hr	
DRY Fd	8710	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.02	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	2 Vessels ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	165	1.0000	5.9128	5,709	2.85	0.66	2.682	2.000
Reactive Hydrocarbons (ROC) as CH_4	92	1.0000	1.1507	1,111	0.56	0.13	0.522	0.389
Carbon Monoxide (CO)	248	1.0000	5.4315	5,244	2.62	0.61	2.464	1.837
Sulfur Dioxide (SO_2)	0.03	1.0000	0.0016	2	0.00	0.00	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0023	1.0000	0.0975	94	0.05	0.01	0.044	0.033
Carbon Dioxide (CO_2)	3.12%	1.0000	1072.6571	1,035,702	518	120	487	363

Gas Emission Factors (AP-42 Table 3.2-2)

NO_X = 2.682 g/kw-hr (CAT Series GLE Engines 2.0 g/bhp-hr)

VOC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

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Table FW 4: Tug/Supply Vessel Activity Summary

Assist Tugs

Berthing Activity	Miles	Speed	Time, hrs	Mains	Weighted	Mode 1	Mode 2	Gens	Weighted	Mode 1	Mode 2
Standby/Patrol to LNG Carrier	3	18.5	0.16	51%	0.3%	2.7%	1.0%	50%	0.3%	0.7%	0.2%
Assist Carrier to FSRU	3	5	0.60	43%	1.1%	8.4%	3.0%	50%	1.2%	2.5%	0.9%
Assist Big Push			0.04	100%	0.2%	1.3%	0.5%	50%	0.1%	0.2%	0.1%
Safety Zone	0.3	1	0.30	22%	0.3%	2.1%	0.8%	50%	0.6%	1.2%	0.5%
Unload Standby/Patrol Safety Zone	0	min	21.80	10%	9.1%	70.9%	25.6%	50%	45.4%	90.8%	32.8%
Safety Zone	0.3	1	0.30	22%	0.3%	2.1%	0.8%	50%	0.6%	1.2%	0.5%
Safety Zone Big Push			0.04	100%	0.2%	1.3%	0.5%	50%	0.1%	0.2%	0.1%
Assist Carrier to Release	3	5	0.60	43%	1.1%	8.4%	3.0%	50%	1.2%	2.5%	0.9%
Release to Standby/Patrol	3	18.5	0.16	51%	0.3%	2.7%	1.0%	50%	0.3%	0.7%	0.2%
Composite			**24.00**		**13%**	**100.0%**	**36.1%**		**50.0%**	**100.0%**	**36.1%**
Two Vessels (per week)			120.0								

Remarks - Berthing

2.5 berthings/wk = 130 berthings/yr
2.5 berthings/wk x 24 hrs x 2 vessels = 120 hrs/wk @ 13% power on mains
ship generators run all the time, so
2.5 berthings/wk x 24 hrs x 2 vessels = 120 hrs/wk @ 50% power on gens

Federal Waters Transit	Miles	Speed	Time, hrs	Mains	Weighted	Mode 1	Mode 2	Gens	Weighted	Mode 1	Mode 2
Loiter to Safety Zone	0.7	5	0.1	14%	0.5%	3.3%	0.1%	50%	1.7%	3.5%	0.1%
Safety Zone	0.3	1	0.3	12%	0.9%	6.1%	0.1%	50%	3.7%	7.5%	0.2%
Load/Unload Safety Zone	0	stop	2.3	0%	0.0%	0.0%	0.0%	50%	28.7%	57.3%	1.4%
Safety Zone	0.3	1	0.3	12%	0.9%	6.1%	0.1%	50%	3.7%	7.5%	0.2%
Cruise from Safety Zone to Boundary	18	18.5	1.0	51%	12.4%	84.4%	2.0%	50%	12.1%	24.2%	0.6%
Composite Each Way			**4.0**		**15%**	**100.0%**	**2.4%**		**50.0%**	**100.0%**	**2.4%**
Round Trip (per week)			8.0								

Remarks - Federal Waters Transit

1 roundtrip/week = 52 roundtrips/year
1 trips/wk x 8 hr/trip = 8 hrs/wk @ 15% power on mains
ship generators run all the time, so
1 trips/wk x 8 hr/trip = 8 hrs/wk @ 50% power on gens

Time Balance (hrs/wk)	Miles	Speed	Time, hrs	Mains	Weighted	Mode 1	Mode 2	Gens	Weighted	Mode 1	Mode 2
Hours per week (2 vessels)			336								
District Waters & Port Time			4								
In Federal Waters			332								
Berthing Activity			120	13%	4.6%						
Transit			8	15%	0.4%						
Standby/Patrol Safety Zone (balance)			204	10%	6.1%	100.0%	61.4%	50%	50.0%	100.0%	61.4%
Total Time in Federal Waters			**332**		**11%**	**100.0%**	**61.4%**		**50%**	**100.0%**	**61.4%**
Per Year			17,264		11%				50%		

Remarks - Federal Waters

52 wks/yr x 332 hrs/wk = 17,264 hrs/yr (2 vessels) @ 11% power on mains
ship generators run all the time, so
17,264 hrs/yr @ 50% power

	29,780,400 Modal Wt	28,485,600 Mains	1,294,800 Gens
Assist/Standby/Loiter	8.3%	8.6%	2.4%
Safety Zone/Patrol	89.7%	89.4%	95.6%
Load/Unload	0.1%	0.0%	1.4%
Transit to/from Boundary/Limit	2.0%	2.0%	0.6%
	100.0%	100.0%	100.0%

Table FW 5: Crew Boat Main Engine Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Crew Boat Main Engines, 1500 BHP		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S		
TOTAL YEARLY PROCESS RATE	468	MW-hrs	
HOURLY PROCESS RATE	0.51	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	1500	BHP	from BHP estimates
LOAD FACTOR	46%	percent	from activity profile
OPERATING SCHEDULE	910	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	5.02	mmBTU/hr	
DRY Fd	8710	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.15	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	165	1.0000	5.9128	2,769	1.38	3.04	2.682	2.000
Reactive Hydrocarbons (ROC) as CH_4	92	1.0000	1.1507	539	0.27	0.59	0.522	0.389
Carbon Monoxide (CO)	248	1.0000	5.4315	2,543	1.27	2.79	2.464	1.837
Sulfur Dioxide (SO_2)	0.03	1.0000	0.0016	1	0.00	0.00	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0023	1.0000	0.0975	46	0.02	0.05	0.044	0.033
Carbon Dioxide (CO_2)	3.12%	1.0000	1072.6571	502,253	251	552	487	363

Gas Emission Factors (AP-42 Table 3.2-2)

NO_X = 2.682 g/kw-hr (CAT Series GLE Engines 2.0 g/bhp-hr)

VOC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

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Table FW 6: Crew Boat Generator Engines Emissions Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	Crew Boat Generator Engine, 150 BHP		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S		
TOTAL YEARLY PROCESS RATE	51	MW-hrs	
HOURLY PROCESS RATE	0.06	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	150	BHP	from BHP estimates
LOAD FACTOR	50%	percent	from activity profile
OPERATING SCHEDULE	910	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	0.55	mmBTU/hr	
DRY Fd	8710	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.017	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	165	1.0000	5.9128	301	0.15	0.33	2.682	2.000
Reactive Hydrocarbons (ROC) as CH_4	92	1.0000	1.1507	59	0.03	0.06	0.522	0.389
Carbon Monoxide (CO)	248	1.0000	5.4315	276	0.14	0.30	2.464	1.837
Sulfur Dioxide (SO_2)	0.03	1.0000	0.0016	0	0.00	0.00	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0023	1.0000	0.0975	5	0.00	0.01	0.044	0.033
Carbon Dioxide (CO_2)	3.12%	1.0000	1072.6571	54,593	27	60	487	363

Gas Emission Factors (AP-42 Table 3.2-2)

NO_X = 2.682 g/kw-hr (CAT Series GLE Engines 2.0 g/bhp-hr)

VOC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

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Table FW 7: Crew Boat Activity Summary

Crew Boats

Support Activity	Miles	Speed	Time, hrs	Mains	Weighted	Mode	Gens	Weighted	Mode
Boundary to FSRU	18	18	1.00	90%	18.0%	39.2%	50%	10.0%	20.0%
Loiter FSRU	1.5	2	0.75	19%	2.9%	6.2%	50%	7.5%	15.0%
Safety Zone	0.3	1	0.30	16%	1.0%	2.1%	50%	3.0%	6.0%
Load/Unload Standby	0	stop	0.90	13%	2.3%	5.1%	50%	9.0%	18.0%
Safety Zone	0.3	1	0.30	16%	1.0%	2.1%	50%	3.0%	6.0%
Loiter FSRU	1.5	2	0.75	19%	2.9%	6.2%	50%	7.5%	15.0%
Cruise to Boundary	18	18	1.00	90%	18.0%	39.2%	50%	10.0%	20.0%
Composite			**5.00**		**46%**	**100.0%**		**50%**	**100.0%**
Per Year			**910**		46%			50%	

Remarks - Federal Waters Transit

1 roundtrip/berthing = 2.5 per week + 1 crew change/week = 3.5 roundtrips/week or 182 roundtrips/year
182 trips/yr x 5 hrs/trip = 910 hrs/yr @ 46% power on mains
ship generators run all the time, so
182 trips/yr x 5 hrs/trip = 910 hrs/yr @ 50% power

BHP-hr/yr	696,150	627,900	68,250
	Modal Wt	**Mains**	**Gens**
Assist/Standby/Loiter	14.1%	12.4%	30.0%
Safety Zone/Patrol	4.9%	4.2%	12.0%
Load/Unload	6.4%	5.1%	18.0%
Transit to/from Boundary/Limit	74.6%	78.3%	40.0%
	100.0%	100.0%	100.0%

Table FW 8: LNG Carrier Vessel Emission Summary

SIC	1321		
PROCESS EQPT DESCRIPTION	LNG Carrier, 60,000 BHP Total		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S & 15 ppmw S California diesel pilot charge		
TOTAL YEARLY PROCESS RATE	16752	MW-hrs	
HOURLY PROCESS RATE	5.37	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	60000	BHP	from BHP estimates
LOAD FACTOR	12%	percent	from activity profile
OPERATING SCHEDULE	3120	hrs/yr	from activity profile
HEAT RATE	8533	BTU/KW-hr	
CONVERSION EFFICIENCY	40.0%	percent	
HEAT INPUT	45.81	mmBTU/hr	
DRY Fd	8713	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	1.41	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CORR FACTOR	CTL EF LBS/UNIT	ACTUAL LBS/YR	ACTUAL TONS/YR	ACTUAL LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	235	1.0222	7.3875	123,752	61.88	39.66	3.351	2.499
Reactive Hydrocarbons (ROC) as CH_4	92	0.9976	1.0044	16,826	8.41	5.39	0.456	0.340
Carbon Monoxide (CO)	249	1.0042	4.7726	79,948	39.97	25.62	2.165	1.614
Sulfur Dioxide (SO_2)	0.03	1.0654	0.0015	25	0.01	0.01	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0024	1.0720	0.0915	1,532	0.77	0.49	0.0415	0.031
Carbon Dioxide (CO_2)	3.13%	1.0040	942.3293	15,785,597	7,893	5,059	427	319

Gas Emission Factors (AP-42 Table 3.2-2)

NO_X = 0.847 lb/mmBTU

ROC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppmv S gas)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

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Table FW 9: LNG Carrier Vessel Activity Summary

LNG Carriers

Berthing Activity	Miles	Speed	Time, hrs	BHP	Percent	Weighted	Mode
25 to 16 miles	9.0	12	0.75	28500	48%	1.5%	12.4%
16 to 13 miles	3.0	5	0.60	11400	19%	0.5%	4.0%
Safety Zone	0.3	1	0.30	5440	9%	0.1%	0.9%
Unload	0.0	stop	20.70	5440	9%	7.8%	65.4%
Safety Zone	0.3	1	0.30	5440	9%	0.1%	0.9%
13 to 16 miles	3.0	5	0.60	11400	19%	0.5%	4.0%
16 to 25 miles	9.0	12	0.75	28500	48%	1.5%	12.4%
Composite			**24.00**			**12%**	**100.0%**
Per Year			3120			12%	

Remarks - Federal Waters Transit

2.5 berthings/wk = 130 berthings/yr

130 berthings/yr x 24 hrs = 3120 hrs/yr @ 12% power

	Modal Wt	Mode
Assist/Standby/Loiter	7.9%	7.9%
Safety Zone/Patrol	1.9%	1.9%
Load/Unload	65.4%	65.4%
Transit to/from Boundary/Limit	24.8%	24.8%
	100.0%	100.0%

ATTACHMENT 3
REVISED APPENDIX C

The Appendix C denoted "Revised 4/6/06" should replace the Appendix A in the December 2005 Minor New Source Review Construction Permit Application in its entirety.

FSRU Emission Factors

Wartsila 9L50DF Main Generators (3)	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	0.075	g/bhp-hr	7.5	ppmv @ 15% O_2	BACT, Wartsila Specification, 16 March 06	99.4% gasified LNG / 0.6% CA diesel (by heat input), 42.9% efficiency
Reactive Hydrocarbons (ROC) as CH_4	0.149	g/bhp-hr	43	ppmv @ 15% O_2	BACT, Wartsila Specification, 16 March 06	
Carbon Monoxide (CO)	0.127	g/bhp-hr	21	ppmv @ 15% O_2	BACT, Wartsila Specification, 16 March 06	
Sulfur Dioxide (SO_2)	0.0005	g/bhp-hr	0.03	ppmv @ 15% O_2	Scarborough LNG / CA diesel specifications	
Particulates (as PM_{10})	0.04937	g/bhp-hr	0.0042	grains/dscf	BACT, Wartsila Specification, 16 March 06	
Carbon Dioxide (CO_2)	331	g/bhp-hr	3.5%	percent volume	Wartsila Report 4 July 03	
Ammonia Slip (NH_3)	0.037	g/bhp-hr	10	ppmv @ 15% O_2	BACT, VCAPCD (permit engineering, 2003)	

Wartsila 9L50DF Backup Generator (1)	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	1.59	g/bhp-hr	150	ppmv @ 15% O_2	BACT, Wartsila Specification, 13 May 05	CA diesel, 15 ppmw S, 42.4% efficiency
Reactive Hydrocarbons (ROC) as CH_4	0.22	g/bhp-hr	60	ppmv @ 15% O_2	BACT, Wartsila Specification, 13 May 05	
Carbon Monoxide (CO)	0.16	g/bhp-hr	25	ppmv @ 15% O_2	BACT, Wartsila Specification, 13 May 05	
Sulfur Dioxide (SO_2)	0.0042	g/bhp-hr	0.29	ppmv @ 15% O_2	CA diesel, 15 ppmw S	
Particulates (as PM_{10})	0.116	g/bhp-hr	0.0092	grains/dscf	BACT, Wartsila Specification, 13 May 05	
Carbon Dioxide (CO_2)	388	g/bhp-hr	3.8%	percent volume	Wartsila specification 50DF, diesel	

Firewater Pump (3)	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	4.18	g/bhp-hr	326	ppmv @ 15% O_2	USEPA Tier 2 Standards (>560 kw)	CA diesel, 15 ppmw S, 35% efficiency
Reactive Hydrocarbons (ROC) as CH_4	0.60	g/bhp-hr	134	ppmv @ 15% O_2	USEPA Tier 2 Standards (>560 kw)	
Carbon Monoxide (CO)	2.61	g/bhp-hr	334	ppmv @ 15% O_2	USEPA Tier 2 Standards (>560 kw)	
Sulfur Dioxide (SO_2)	0.0051	g/bhp-hr	0.29	ppmv @ 15% O_2	CA diesel, 15 ppmw S	
Particulates (as PM_{10})	0.149	g/bhp-hr	0.0097	grains/dscf	USEPA Tier 2 Standards (>560 kw)	
Carbon Dioxide (CO_2)	522	g/bhp-hr	4.3%	percent volume	USEPA AP-42, Table 3.3-1	

Revised 4/6/06

FSRU Emission Factors

Emergency Generator (1)	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	4.18	g/bhp-hr	372	ppmv @ 15% O_2	USEPA Tier 2 Standards (>560 kw)	CA diesel, 15 ppmw S, 40% efficiency
Reactive Hydrocarbons (ROC) as CH_4	0.60	g/bhp-hr	153	ppmv @ 15% O_2	USEPA Tier 2 Standards (>560 kw)	
Carbon Monoxide (CO)	2.61	g/bhp-hr	382	ppmv @ 15% O_2	USEPA Tier 2 Standards (>560 kw)	
Sulfur Dioxide (SO_2)	0.0045	g/bhp-hr	0.29	ppmv @ 15% O_2	CA diesel, 15 ppmw S	
Particulates (as PM_{10})	0.149	g/bhp-hr	0.0111	grains/dscf	USEPA Tier 2 Standards (>560 kw)	
Carbon Dioxide (CO_2)	522	g/bhp-hr	4.9%	percent volume	USEPA AP-42, Table 3.3-1	

Freefall Lifeboats (3)	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	4.85	g/bhp-hr	324	ppmv @ 15% O_2	USEPA Tier 2 Standards (>37 kw, <75 kw)	CA diesel, 15 ppmw S, 30% efficiency
Reactive Hydrocarbons (ROC) as CH_4	0.75	g/bhp-hr	143	ppmv @ 15% O_2	USEPA Tier 2 Standards (>37 kw, <75 kw)	
Carbon Monoxide (CO)	3.73	g/bhp-hr	410	ppmv @ 15% O_2	USEPA Tier 2 Standards (>37 kw, <75 kw)	
Sulfur Dioxide (SO_2)	0.0060	g/bhp-hr	0.29	ppmv @ 15% O_2	CA diesel, 15 ppmw S	
Particulates (as PM_{10})	0.298	g/bhp-hr	0.0167	grains/dscf	USEPA Tier 2 Standards (>37 kw, <75 kw)	
Carbon Dioxide (CO_2)	522	g/bhp-hr	3.6%	percent volume	USEPA AP-42, Table 3.3-1	

Selas Sub-X Low Emission SCVs (8)	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	0.0243	lb/mmbtu	20	ppmv @ 3% O_2	Selas Specification, Sub-XLE, 120-180 t/hr	100% gasified LNG
Reactive Hydrocarbons (ROC) as CH_4	0.0017	lb/mmbtu	4.1	ppmv @ 3% O_2	Costain Report 6407-0200-064-01-0001, Appx. 1	
Carbon Monoxide (CO)	0.0739	lb/mmbtu	100	ppmv @ 3% O_2	Selas Specification, Sub-XLE, 120-180 t/hr	
Sulfur Dioxide (SO_2)	0.0002	lb/mmbtu	0.10	ppmv @ 3% O_2	Scarborough LNG specification, 1 ppmv S	
Particulates (as PM_{10})	0.0019	lb/mmbtu	0.0013	grains/dscf	USEPA AP-42, Table 1.4-2, non-condensible	
Carbon Dioxide (CO_2)	106.8	lb/mmbtu	9.2%	percent volume	Selas Specification, Sub-XLE, 120-180 t/hr	

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Operating Vessels Emission Factors

LNG Carriers	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	2.50	g/bhp-hr	235	ppmv @ 15% O_2	USEPA AP-42, Tables 3.2-2 & 3.4-1	99.2% gasified LNG / 0.8% CA diesel by heat input, 40% efficiency
Reactive Hydrocarbons (ROC) as CH_4	0.34	g/bhp-hr	92	ppmv @ 15% O_2	USEPA AP-42, Tables 3.2-2 & 3.4-1	
Carbon Monoxide (CO)	1.61	g/bhp-hr	249	ppmv @ 15% O_2	USEPA AP-42, Tables 3.2-2 & 3.4-1	
Sulfur Dioxide (SO_2)	0.0005	g/bhp-hr	0.03	ppmv @ 15% O_2	Scarborough LNG / CA diesel specifications	
Particulates (as PM_{10})	0.031	g/bhp-hr	0.0024	grains/dscf	USEPA AP-42, Tables 3.2-2 & 3.4-1	
Carbon Dioxide (CO_2)	319	g/bhp-hr	3.1%	percent volume	USEPA AP-42, Tables 3.2-2 & 3.4-1	

Tug Supply Boats (2)	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	0.97	g/bhp-hr	80	ppmv @ 15% O_2	Wartsila Specification, 16 March 06	99.2% gasified LNG / 0.8% CA diesel by heat input, generators 100% gasified LNG, 35% efficiency
Reactive Hydrocarbons (ROC) as CH_4	0.39	g/bhp-hr	92	ppmv @ 15% O_2	Wartsila Specification, 16 March 06	
Carbon Monoxide (CO)	1.42	g/bhp-hr	192	ppmv @ 15% O_2	Wartsila Specification, 16 March 06	
Sulfur Dioxide (SO_2)	0.0006	g/bhp-hr	0.03	ppmv @ 15% O_2	Scarborough LNG / CA diesel specifications	
Particulates (as PM_{10})	0.048	g/bhp-hr	0.0033	grains/dscf	Wartsila Quote, 16 February 06	
Carbon Dioxide (CO_2)	349	g/bhp-hr	3.0%	percent volume	Wartsila Report 4 July 03	

Crew Boat (1)	Factor	Units	Conc.	Units	Emission Factor Reference	Fuel
Nitrogen Oxides (as NO_2)	2.00	g/bhp-hr	165	ppmv @ 15% O_2	CAT Series GLE Engines	100% gasified LNG, 35% efficiency
Reactive Hydrocarbons (ROC) as CH_4	0.39	g/bhp-hr	92	ppmv @ 15% O_2	USEPA AP-42, Table 3.2-2	
Carbon Monoxide (CO)	1.84	g/bhp-hr	248	ppmv @ 15% O_2	USEPA AP-42, Table 3.2-2	
Sulfur Dioxide (SO_2)	0.0005	g/bhp-hr	0.03	ppmv @ 15% O_2	Scarborough LNG specification, 1 ppmv S	
Particulates (as PM_{10})	0.033	g/bhp-hr	0.0023	grains/dscf	USEPA AP-42, Table 3.2-2	
Carbon Dioxide (CO_2)	363	g/bhp-hr	3.1%	percent volume	USEPA AP-42, Table 3.2-2	

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1. WÄRTSILÄ 50DF LNG FSRU POWER PLANT EXHAUST GAS EMISSIONS

The report describes the values that are achievable with the 50DF engines for the Cabrillo port LNG terminal project. Guarantees of these values are included in a technical specification and offer. In the chapter 1.2 the emission levels out of the engine are described and in chapter 1.3 the emissions out of a power plant fitted with emission reduction methods and analysed. It should be notable that the one emission level given is this document can be further improved but might have negative impact on other emissions levels. Therefore; if some special emission requirements occur they can be treated case by case.

All measurements and emission limits are done according to chapter 1.4.

1.1 FUEL DATA

The exhaust gas emissions are given according to a fuel gas specification below:

1.1.1 Gas specification (at 0 °C , 100 kPa)

	vol %
CH4	99,66804
C2H6	0,111987
C3H8	0
n-C4H10	0
i-C4H10	0,009999
n-C5H12	0
i-C5H12	0
n-C6H14	0
n-C7H16	0
N2	0,189977203
O2	0,0099988
CO2	0,0099988
H2S	0
H2	0
H2O	0
CO	0
Ar	0
He	0

1.2 50DF ENGINE EMISSONS

Table 1. Emission levels from 50DF engine without emission reduction (1

FUEL : Natural gas (2					
Unit	NO_x	CO	VOC	SO_x	$PM_{10,dry}$
g/kWh	1.5	1.06	0.431	0.0759	0.0662
Vol-ppm, dry at 15% O_2	135	128	87	4	
mg/m3					10

FUEL : Marine diesel oil					
g/kWh	14,7	1.03	0.651	0.0835	0.154
Vol-ppm, dry at 15% O_2	970	111	123	4	
mg/m3					21

(1 Values given at 90% load

(2 only valid with the fuel gas defined

1.3 50DF POWER PLANT (WITH SCR AND OXIDATION CATALYST) EMISSIONS

This chapter describes the emission limits that are achievable with appropriate emission reduction methods on a 50DF power plant. The emission reduction can be optimised for gas fired operation or Marine diesel operation. This project focus on utilising natural gas as fuel and therefore the values are optimised according to gaseous fuel operation.

The emission levels on diesel can also be reduced; however these are not of highest priority and therefore not optimised in this evaluation.

Table 2. Emission levels from 50DF power plant with SCR and oxidation catalysts emission reduction (1

FUEL : Natural gas (2					
Unit	NO_x	CO	VOC	SO_x	$PM_{10, dry}$
g/kWh	0.10	0.17	0.20	0.0759	0.0662
Vol-ppm, dry at 15% O_2	9	20	40	4	
mg/m3					10
FUEL : Marine diesel oil					
g/kWh	14,7	1.03	0.651	0.0835	0.154
Vol-ppm, dry at 15% O_2	970	111	123	4	
mg/m3					21

(1 Values given at 90% load

(2 only valid with the fuel gas defined

This chapter describes emission levels that are achievable with a DF power plant fitted with selective catalytic reduction. The values are only valid for Wärtsilä supplied equipment. The technical particulars are only described in the technical specification.

1.4 MEASURING METHODS

Emission values are based on and valid only on following or principally similar measurement methods and limits:

1.4.1 Nitrogen oxides (NOx)

USA EPA Method 7E: Determination of nitrogen oxides from stationary sources

(instrumental analyzer method).

1.4.2 Sulphur oxides (SOx)

After engine (no deSOx equipment installed)

ISO/CD 8178-1 : Sulphur oxides are calculated from sulphur content in the fuel.

1.4.3 Carbon monoxide (CO)

USA EPA Method 10 : Determination of carbon monoxide emissions from stationary sources.

1.4.4 Total Hydrocarbons (THC)

USA EPA Method 25A: Determination of total gasous organic concentration using a flame ionisation analyzer (FID).

1.4.5 VOC (NM/NEHC) after engine (no catalyst installed)

USA EPA Method 25A: Determination of total gasous organic concentration using a flame ionisation analyser. None Methane None Ethane Hydrocarbons are defined as total hydrocarbons (THC) excluding metane and ethane. The methane and ethane concentrations in the exhaust gas are calculated based on the fuel analysis. The ratio of methane and ethane to THC in the fuel gas remain constant in the exhaust gas.

1.4.6 VOC (NM/NEHC) after an oxidation catalyst

USA EPA Method 18: Measurement of gaseous organic compound emissions by gas chromatography. VOC is defined as Non Methane Non Ethane Hydrocarbons. Measured components are C3H8, C4H10, C5H12, C6H14, C2H4, C3H6, C4H8, C5H10 and C6H12. Formaldehyde concentration is negligible after a catalyst. If required this can be verified with method CTM-037.

1.4.7 Particulates

PM (Particulate matter as dry dust).

ISO 9096: Determination of particulate emissions from stationary sources (in stack method)

USA EPA Method 17: Determination of particulate emissions from stationary sources (in-stack method).

1.4.8 Filterable PM10

USA EPA Method 17: Determination of particulate emissions from stationary sources (in-stack method)

USA EPA Method 201A (front half): Determination of filterable PM10 emissions

(in-stack filter method with sizing device)

1.4.9 PM (Particulate matter as dry dust) when flue gas temperature is < 160C eg after heat recovery boiler

ISO 9096: Determination of particulate emissions from stationary sources.

USA EPA Method 5B: Determination of particulate emissions from stationary sources.

1.4.10 Measurement uncertainties

Measurement uncertainties to be evaluated by the party that carries out the measurement.

The assessment of the guarantee fulfilment to be performed according to Section 6.2 of the VDI 2048 guidelines.